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ASSESSMENT OF THE IMPACT OF WASTE FROM POULTRY HATCHERY AND POSTCELLULOSE LIME ON SELECTED INDEXES OF LIGHT SOIL FERTILITY

OCENA ODDZIAŁYWANIA ODPADU Z WYLĘGARNI DROBIU ORAZ WAPNA POCELULOZOWEGO NA WYBRANE WSKAŹNIKI ŻYZNOŚCI GLEBY LEKKIEJ

Abstract: The effect of conditioned waste from poultry hatchery on selected parameters of light soil was examined. Basing on the obtained results it was found that after applying the conditioned waste, the contents of organic matter increased, which was manifested in the increase in both mean content of organic carbon and total nitrogen in soil. Furthermore, a mean significant increase in the contents of available forms of phosphorus and magnesium was also found. As the effect of applying both the organic waste from poultry hatchery and the postcellulose lime, a significant increase in exchangeable acidity and a decrease in contents of available forms of potassium were observed with reference to the control. The use of postcellulose lime reduced the contents of available forms of magnesium in soil.

Keywords: waste from poultry hatchery, postcellulose lime, organic matter, light soil, soil fertility

In many branches of industry including food industry, considerable amounts of industrial waste are produced, the nature uses of which are limited by strict legal rules and regulations. Many of the waste types are rich in organic substance containing macro- and microelements of high fertilizing value. Both a considerable fraction of light soils in the area of our country and a negative balance of organic matter in arable soils justify the interest in these types of wastes. One of them is the waste from poultry hatcheries and, owing to considerable amount of calcium (approx. 40 % CaO), it can improve soil fertility inducing changes in values of acidity indexes.

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The aim of this study was to assess the usefulness of soil conditioner containing the waste from poultry hatchery and postcellulose lime on the value of selected indexes of light soil fertility.

Material and methods

A strict one-factor field experiment was carried out in 2005–2007 in Ciele, near Bydgoszcz, to assess the effect of conditioned waste from poultry hatchery and postcellulose lime on selected parameters of light soil. The experiment was established in Luvisols of 6th class (clay fractions content – 4 %) characterised by very acid reaction, low abundance in available forms of phosphorus and potassium, and mean abundance in available forms of magnesium. The tested factor of the experiment was a soil conditioner applied in two doses: 2 Mg · ha^{-1} and 4 Mg · ha^{-1}. The experiment was carried out in a system of randomized blocks with three replications. An area of the experimental plot was 40 m^2. In the farm where the experiment was carried out, no root crops were cultivated, so spring triticale was the test plant in the first year of the study and oat in the second and third years. Soil conditioner dosages were established in such a way that no more than 170 kg N · ha^{-1} was introduced into soil together with the organic material.

The soil conditioner from poultry hatchery included: waste eggs rejected from the incubating process, cracked, not-fertilised, and dead eggs, and dead and invalid chicks. This material, mixed with sawdust, was hygienised with calcium oxide and stored in prism for six months. The chemical composition of soil conditioner and postcellulose lime are presented in Tables 1 and 2.

Table 1

The proporties of soil conditioner from poultry hatchery

Parameter	Unit	Value
pH in H_2O	pH	12.0
Dry matter (d.m.)	[%]	51.0
Organic matter	[g · kg^{-1}]	603.0
Total nitrogen (N)		72.6
Ammonium nitrogen (NH_4-N)		1.98
Total phosphorus (P)		1.60
Potassium (K)		2.10
Calcium (Ca)		290.0
Magnesium (Mg)		3.50

The conditioned waste from the poultry hatchery contained 40 % CaO (Table 1). Therefore the scheme of experiment apart from control object, included also the objects on which postcellulose lime was used (Table 2) in the amount equivalent to the dose of the component contained in the applied conditioner. Both tested conditioner from poultry hatchery and calcium fertilizer were applied in autumn 2004.

Table 2

The chemical composition of postcellulose lime

Parameter	Unit	Content
CaO	[%]	40
Chloride (Cl)		2.85
Sulphur (S)		1.1

Five fertilizing objects were taken into consideration:
– K – the control (mineral fertilisation only),
– S_1 – soil conditioner in a dose of 2 Mg · ha^{-1},
– S_2 – soil conditioner in a dose of 4 Mg · ha^{-1},
– Ca_1 – postcellulose lime in a dose of 1 Mg · ha^{-1},
– Ca_2 – postcellulose lime in a dose of 2 Mg · ha^{-1}.

In every year of the field experiment, after the plant harvest time, soil samples were taken from the soil layer (0–25 cm) to determine their indexes as follows: exchangeable acidity, the contents of avalilable forms of potassium and phosphorus determined by the Egner-Riehm (DL) method, magnesium by AAS method. Additionally, there were determined: total nitrogen by Kjeldahl's method, and the content of organic carbon in soil with Tiurin's method.

The results obtained were statistically performed by using variance analysis and Tukey's test at the level of significance $\alpha = 0.05$.

Results and discussion

It was found that the applied soil conditioner and the postcellulose lime induced changes in soil pH values with reference to the control (Table 3). In all the analysed soil samples the values of pH were higher than the pH value determined for the control (pH_{KCl} 4.4). The highest value of pH (4.7) with reference to the control was found in the soil where the conditioner from poultry hatchery was applied in a dose of 4 Mg · ha^{-1}. The same conditioner used in a dose of 2 Mg · ha^{-1} resulted in the increase in pH-values by 0.2 unit on average with reference to the control. Under the influence of postcellulose lime the pH value was shaped independently on the dose applied, on average at the level of 4.5. It is worth noticing that the used waste materials as components of the tested conditioner induced changes of soil reaction in comparison with the control, from the very acidic into acidic one.

The effect of waste organic materials on soil reaction (pH) is not explicit. It depends on chemical composition mostly and it is connected with their origins [1, 2]. Dechnik and Wiater [1] report about acidifying organic waste on the basis of molasses and straw extraction. In turn, Gondek and Filipek-Mazur [3] demonstrate advantageous effect of tanning sediments on the increase in soil pH value. The extracts (from molasses, rye and potato) used in the research of Łabętowicz et al [4] showed less clear influence on soil reaction. However, no change in soil reaction (pH) was stated under the effect of applied compost consisted of straw, sawdust and lignite [5].

Table 3

Impact of conditioner from poultry hatchery and postcellulose lime on selected soil properties

Years of study	Fertilisation objects/Parameter					Mean	$LSD_{0.05}$
	Control	S_1	S_2	Ca_1	Ca_2		
	pH in KCl						
2005	4.4	4.7	4.9	4.6	4.5	4.7	
2006	4.5	4.5	4.6	4.5	4.6	4.5	
2007	4.4	4.5	4.7	4.4	4.5	4.5	
Mean	4.4	4.6	4.7	4.5	4.5	4.5	
C-organic [g C · kg^{-1}]							
2005	5.87	8.32	7.25	6.12	6.16	6.74	0.833
2006	6.65	7.96	7.64	6.48	6.69	7.09	0.860
2007	6.36	7.67	7.54	6.44	6.16	6.84	0.834
Mean	6.29	7.98	7.48	6.35	6.34	6.89	0.248
Nitrogen content [g N · kg^{-1}]							
2005	0.61	0.73	0.74	0.53	0.60	0.64	0.174
2006	0.68	0.72	0.75	0.55	0.60	0.66	0.046
2007	0.64	0.70	0.74	0.53	0.60	0.64	0.101
Mean	0.64	0.72	0.74	0.54	0.60	0.65	0.053
P – available [mg P · kg^{-1}]							
2005	33.77	40.27	38.23	27.63	28.63	33.71	2.646
2006	27.87	38.90	36.60	26.83	29.50	30.34	3.446
2007	28.20	38.53	35.43	25.87	30.30	29.95	3.025
Mean	29.95	36.57	36.76	26.78	29.48	31.90	0.901
K – available [mg K · kg^{-1}]							
2005	37.10	38.10	35.03	34.07	33.80	35.62	3.119
2006	46.27	31.27	32.37	33.47	31.60	34.99	4.480
2007	38.57	33.80	31.87	32.93	32.07	33.85	3.509
Mean	40.65	34.39	33.09	33.49	32.49	34.82	1.045
Mg – available [mg Mg · kg^{-1}]							
2005	23.53	23.40	24.50	21.37	21.73	23.77	1.792
2006	23.57	24.53	25.53	21.27	22.33	23.45	1.706
2007	23.57	24.13	24.43	20.83	21.73	22.94	1.434
Mean	23.56	24.02	24.82	21.16	21.93	23.10	0.427

The study revealed that the highest content of organic carbon was found in the soil where soil conditioner was applied in doses 2 Mg · ha^{-1} and 4 Mg · ha^{-1} (7.98 g · kg^{-1} and 7.48 g · kg^{-1}, respectively). Considering the control, the growth was on average 26.9 % and 18.9 %. Worth noticing is the fact that the content of organic carbon in soil on the plot where lower dose of the conditioner was used lowered as the years passed. Also in the research by Wiater and Dębicki [6], soil organic carbon was systematically

reduced under the effect of sewage sludge as the research years went by. Mean carbon content on plots fertilized with defecation lime was slightly higher than in soil of the control. In the research of Skowrońska and Wiater [7], Kopeć et al [8], as well as Gondek and Filipek-Mazur [3] the application of organic waste also induced the increase in soil organic carbon by more than 50 % with reference to the control.

The investigations carried out revealed a clear increase in average content of total nitrogen in soil from the plots where conditioner from poultry hatchery was used with reference to the control. Depending on the conditioner dose the increase ranged from 12.5 % in the plot with a dose of 2 Mg · ha^{-1} up to 15.6 % in a plot with a dose of 4 Mg · ha^{-1}. Fertilisation with postcellulose lime in a dose of 1 Mg · ha^{-1} significantly lowered average total nitrogen content in soil, by 15.6 % with reference to the control. A higher dose of postcellulose lime did not differentiate significantly this element soil fertility, maintaining its value at the level similar to that observed on the unfertilized object.

Since the soil conditioner from poultry hatchery used in the research contained considerable amounts of organic matter and nitrogen, its modifying effect on these parameters is very clear. Worth noticing is the fact that the use of the conditioner in a single or double dose had no effect on diversifying the discussed parameters, which can be explained as its small ability to decay under the condition of the experiment.

The content of available forms of nitrogen in soil was the highest on the objects where soil conditioner from poultry hatchery was used. Comparing with the soil content before starting the field experiment, the increase was on average by 22.1 % in soil applied with a dose of 2 Mg · ha^{-1}, and 22.7 % in soil with dose of 4 Mg · ha^{-1} of the conditioner. The study by Bohacz and Korniłowicz-Kowalska [9] revealed that the application of creatine-bark composts and creatine-bark-straw composts also enriched soil with available forms of phosphorus. However, according to Dechnik and Skowrońska [10], the use of molasses extract and straw contributes to lowering the contents of available forms of this element in soil. In soil of the object where postcellulose lime was used in a dose of 1 Mg · ha^{-1}, an average content of available forms of phosphorus was the lowest and reached 26.78 mg · kg^{-1}. This reduction was significant and by 10.6 % lower with reference to soil in the control. The reduction in available forms of phosphorus was probably induced by acid reaction of soil and the cultivated plants which took up larger amounts of phosphorus as a result of higher nitrogen consumption, using soil reserves. It should be emphasized that the content of available forms of phosphorus was the highest in the first year of the experiment and lowered in the next years on the objects where soil conditioner was used with a lower dose of postcellulose lime. The decline in available forms of this element may be explained by acid soil reaction which probably retards some part of phosphorus available for plants.

Basing on the carried out experiment, it was found that average content of available forms of potassium in soil on all fertilized objects was significantly lower with reference to the control. The lowest mean content of available forms of this element was found in soil fertilized with 2 Mg · ha^{-1} of postcellulose lime. This reduction was by 20.07 % in comparison with soil from the control object. The conditioner with dose of 4 Mg · ha^{-1} reduced the content of the available for plants forms of potassium by

18.6 %. These observations confirm the results of the research made by Wiater and Dębicki [6] who used ceratine-bark-ureic granulates. These authors achieved reduction in available forms of potassium in soil even by 20 % in the first year of the experiment and by 10 % in the second one. Whereas an essential increase in potassium available for plants under the effect of applying molasses extract was observed by Dechnik and Skowrońska [10]. According to Gondek and Filipek-Mazur [3], tanning sludge increased soil available potassium forms by 40 % on average. Therefore it is important what waste we use, which is inseparably connected with its chemical composition and its impact on soil properties. The observed reduction in soil available potassium in presented experiment was probably connected with higher absorption of this element by cultivated plants. Since the soil conditioner contained small amounts of potassium, the plants absorbed it from soil resources.

Mean content of available forms of magnesium was the highest in soil of the objects where the conditioner based on the waste from poultry hatchery was used and amounted to 24.82 mg · kg^{-1} and 24.02 mg · kg^{-1}. In comparison with the control, the increase reached 5.3 % when a dose of the conditioner per hectare equaled 4 Mg · ha^{-1} and 1.9 % in case of 2 Mg · ha^{-1} application. Under the effect of fertilizing with postcellulose lime in a dose of 2 Mg · ha^{-1}, the available forms of this element were reduced by approx. 6.9 %, whereas after applying the dose of 1 Mg · ha^{-1} – by 10.2 %. Such considerable differences between the conditioner and postcellulose lime were caused by a nearly 0.4 % content of magnesium in the conditioner which additionally enriched the fertilised soil with that element. In Błazik and Wiater's study [11], sawdust with addition of defecation lime increased available forms of magnesium in soil, but according to Skowrońska and Wiater [7], distillery waste induced a decrease in soil available magnesium by approx. 10 %. Since light soils are formed on loose or clayey sands, their contents of available magnesium forms are connected to the most degree with soil acidity and lower with the reduction in pH value [12]. It contributes to forming of magnesium deficiencies in considerable areas of arable lands [13] and the use of organic wastes may counteract Mg deficit.

Conclusions

1. After using the conditioner containing waste from poultry hatchery, a change in the class of reaction of fertilised soil (as regards pH values) was observed.

2. Under the effect of the used soil conditioner, an increase in average contents of: organic carbon, total nitrogen, available forms of both phosphorus and magnesium was observed, while a decrease in the potassium content was noticed after applying the conditioner and postcellulose lime, with reference to the control.

3. The available forms of phosphorus and potassium content in soil where the conditioner was applied reduced in the years of the experiment.

4. According to the effects of research, the conditioner produced on the basis of poultry hatchery waste caused significant positive changes in chemical properties of very acid and poor light soil. It points out the possibility of practical usage of this product in returning the soil of low agricultural usage its productive ability.

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Abstrakt: Badano wpływ kondycjonowanego odpadu z wylęgarni drobiu oraz wapna pocelulozowego na wybrane parametry gleby lekkiej. Na podstawie uzyskanych wyników badań stwierdzono, że po zastosowaniu kondycjonera glebowego wzrosła zawartość materii organicznej, co przejawiało się wzrostem średniej zawartości węgla organicznego oraz azotu ogółem w glebie. Ponadto stwierdzono w tych warunkach znaczny wzrost średniej zawartości przyswajalnych form fosforu i magnezu w glebie. W wyniku zastosowania zarówno odpadu organicznego z wylęgarni drobiu, jak i wapna pocelulozowego, stwierdzono znaczny wzrost wartości kwasowości wymiennej oraz zmniejszenie zawartości przyswajalnych form potasu w porównaniu z obserwowanymi w obiekcie kontrolnym. Zastosowanie wapna pocelulozowego powodowało zmniejszenie zawartości przyswajalnych form magnezu w glebie.

Słowa kluczowe: odpad z wylęgarni drobiu, wapno pocelulozowe, materia organiczna, gleba lekka, żyzność gleby